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RESEARCH NOTE
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COLUMBUS, OHIO R. D. LANE, DIRECTOR

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VOLUMES OF FIELD SOIL AND OF WATER MEASURED BY SUBSURFACE NUCLEAR PROBES

What is the effective sphere of influence of a subsurface nuclear probe? At what depth can we start taking accurate readings? The data presented in this report help answer these questions.

It is generally felt that the volume of material measured by both the subsurface moisture and density probes depends upon the type of material being measured. So, because we are working mainly with silt loam and clay loam, we designed a field test to measure the effective radius of influence in such soil. A 48-inch-radius cylinder of Keene silt loam soil was isolated and equipped with nuclear meter access tubes. Successive reductions in cylinder radius had no effect on moisture and density probe readings until the radius was reduced below 12 inches.

When the cylinder was cut to less than a 12-inch radius, the readings from both probes fell off sharply in a reverse "S" curve. Readings with the probes held at different distances above and below a water surface gave similar results and curves.

The instruments used in this study were a Nuclear-Chicago, P-19, subsurface-moisture, Nuclear Probe Number 136, and a Nuclear-Chicago, P-20, subsurface-density Nuclear Probe Number 103.[1] The study was conducted in an

1/ Mentioning the name of a manufacturer or his product does not constitute an endorsement or disparagement by the United States Department of Agriculture.

open field near the edge of a mixed-hardwood forest so that soil conditions would be as near forest-like as possible and yet there would be no large roots to contend with. The soil, Keene silt loam, is described by horizons below:

Horizon depth (Inches)	Texture	Structure
0-11	Silt loam	Weak, subangular blocky
11-19	Heavy silt loam	Moderate, coarse, subangular block
19-33	Heavy silt loam	Weak, coarse, subangular blocky
33+	Clay	Massive

After locating a suitable site, we established the center of the plot by sinking a 60- by 1.74-inch electric metallic access tube to a depth of 52 inches. We then took three readings at each 6-inch-depth interval, first with the moisture probe and then with the density probe. To measure possible moisture and density differences due to differences in texture we installed one tube 48 inches north and one 48 inches south of the center tube and took similar readings in these tubes. When no significant differences in soil moisture or bulk density readings at the same depths were found we excavated a circular trench around the plot, 48 inches

FIGURE 1.--Column of soil reduced to second stage with tubes at 36 inches from center tube exposed.

deep. This left a cylindrical column of soil 48 inches high with a 48-inch radius.

We then installed 10 additional tubes at various directions and distances from the center tube. Readings in these tubes were compared and we found no significant differences in soil moisture and density at given depths. We then reduced the radius of the column to 36 inches (fig. 1). We continued making readings and reducing the size of the column until only a 2-inch-thick ring of soil remained around the center tube. Finally, we cut away even these last 2 inches of soil and made readings at different depths with the tube surrounded by air.

RESULTS FROM FIELD BLOCK OF SOIL

Differences in soil moisture and bulk density are expected at different depths in the soils common to the Allegheny-Cumberland Plateau. For this reason, we took readings at vertical intervals of 6 inches.

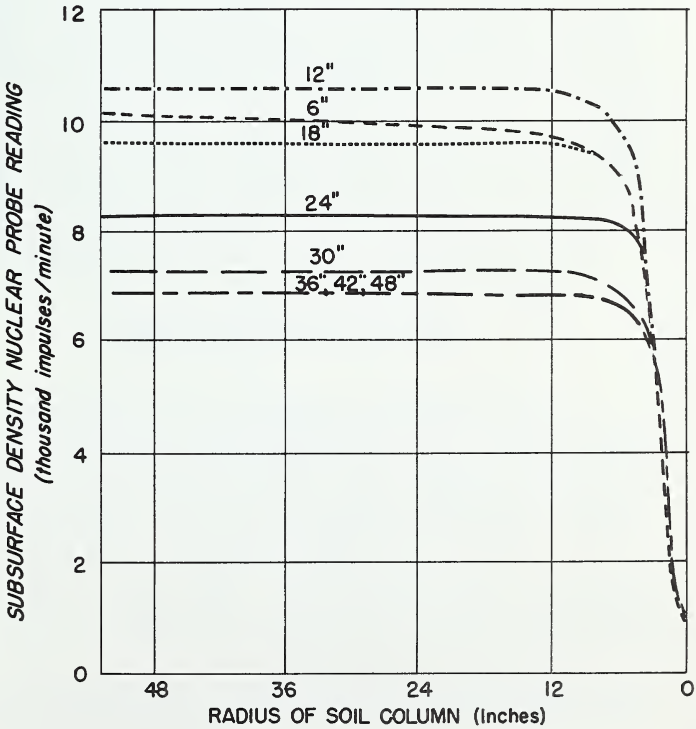

FIGURE 2.--Subsurface density nuclear probe readings for various depths and soil column radii.

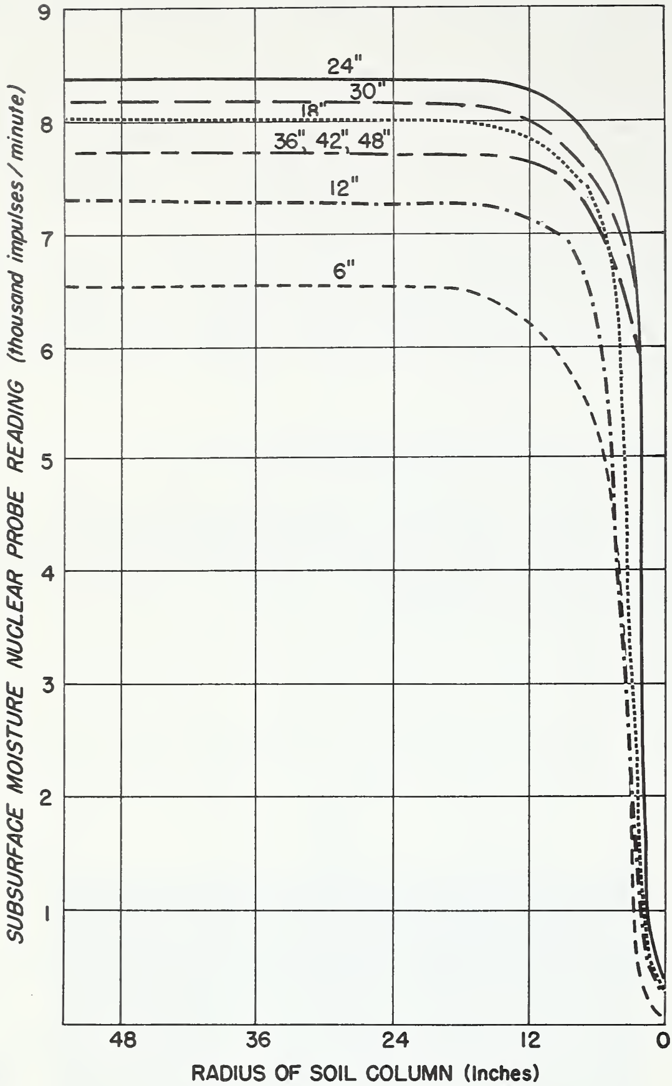

FIGURE 3.--Subsurface moisture nuclear probe readings for various depths and soil column radii.

As expected in view of the textural change from light silt loam in the top horizons to heavy clay at the deeper horizons, there was a small amount of moisture in the top 12 inches, more at 18, 24, and 30 inches, and then a decline and almost uniform quantity of soil moisture in the clay horizon at 36 inches and below (figs. 2 and 3). Bulk densities increased with depth until they became uniform at 30 inches and below.

Density probe readings in the center tube remained uniform until the radius of the cylinder had been reduced to 12

inches (outside edge of tube to outside edge of soil). Further reductions in column size lowered the probe readings (fig. 2) and the lowest reading occurred when the center tube was surrounded by air. This reading represented the standard background impulse rate for that type of tubing. The 10 additional tubes within the soil block furnished similar supporting information.

The moisture probe relations were generally similar except that the initial readings were not as high and the curves had a slightly more pronounced, reverse "S" shape (fig. 3).

RESULTS FROM A POND OF WATER

The volume of water measured by the probes was found by making readings with each probe suspended in an electric metallic access tube at different heights above and below a water surface. Curves from these readings differed somewhat from those obtained in the field block of soil.

In a large body of water moisture is at a maximum, so the sphere of influence of the moisture probe should be at a minimum. Therefore, the moisture probe curve for over- and under-water readings had higher, narrower, and more abrupt changes than the curve for the field block of soil. The radius of the sphere of water measured was 6 inches, whereas the soil sphere radius was 12 inches.

Water does not have an unusually high density, so the water curve for the density probe differed greatly from the water curve of the moisture probe. The radius of the sphere of influence for the density probe was 12 inches in both soil and water.

RECOMMENDATIONS

The size of the sphere of influence varies with the material studied but generally measurements with subsurface density or moisture probes at less than 12 inches below the surface should not be made unless a special calibration is made for the depth and soil in question.

Richard B. Marston, formerly research forester
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For other reports on the performance and characteristics of surface and subsurface nuclear equipment see the following publications by the same author:

"Characteristics of a commercially-available, surface-moisture, nuclear probe," Internatl. Assoc. Sci. Hydrol. Bul. IX[e] No. 2, pp. 80-89.

"Access tubes and timers for use with nuclear soil moisture meters," U.S. Forest Serv. Res. Note CS-30.

"Checking the calibration of nuclear soil moisture and density measuring equipment," U.S. Forest Serv. Res. Note CS-31.